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FURTHER STUDIES ON DRY AND WET SPELL AT MADRAS DURING NORTHEAST MONSOON

1. In India a lot of investigations have been done to study the behaviour of wet and dry spells by applying Markov Chain Model (Basu 1971, Sundararaj and Ramachandra 1975, Medhi 1976, Bhargava et al. 1977, Agnihotri et al. 1984, Pandharinath 1991).

1.1. Recently, Sarkar (1994) has studied the length distribution of weather cycles and dry and wet spells at Madras during northeast monsoon and found that each type of spell and weather cycle obeys the Markov Chain Model. He also found that at Madras the most frequent length of weather cycle cannot be less than 3 days.

1.2. The present study is the further extension of the study made by Sarkar (1994). It aims to present an analysis of basic probabilities, 10-day duration probability of consecutive dry and wet spells of different lengths and also the maximum possible length of dry and wet spell at Madras during northeast monsoon.

2. Daily rainfall data of Madras for 30 years (1961-90) for October, November and December months have been utilized in this study. For defining a day as wet/dry day, rainfall value of 5 mm/day is chosen as threshold value, i.e., a day was wet when it received rainfall of atleast 5 mm/day; otherwise it was a dry day (Sarkar 1994).

2.1. The probabilities of dry day $P(D)$, wet day $P(W)$, dry days preceded by a dry day $P(DD)$, and wet days preceded by a wet day $P(WW)$ have been calculated for each consecutive 10-day period in October, November and December using the following equations:

$$P(D) = F(D)/n \qquad (1)$$

$$P(DD) = F(DD)/F(D) \qquad (2)$$

$$P(W) = F(W)/n \qquad (3)$$

$$P(WW) = F(WW)/F(W) \qquad (4)$$

where, $F(D)$ and $F(W)$ are the frequencies of dry and wet days respectively during a 10-day period; $F(DD)$ is the frequency of dry days preceded by

TABLE 1

The probability of dry days $P(D)$, dry days preceded by a dry day $P(DD)$, wet days $P(W)$, wet days preceded by a wet day $P(WW)$ for each 10-day period in October, November, and December for Madras

10-Day period	$P(D)$ (%)	$P(DD)$ (%)	$P(W)$ (%)	$P(WW)$ (%)
1-10 Oct	77	74	23	19
11-20 Oct	77	79	23	23
21-31 Oct	68	76	32	46
1-10 Nov	60	60	40	47
11-20 Nov	71	75	29	39
21-30 Nov	76	83	24	37
1-10 Dec	75	74	25	34
11-20 Dec	88	89	12	20
21-31 Dec	89	94	11	21

another dry day. $F(WW)$ has similar meaning; n is the period in days, i.e., 10 in the present case.

2.2. Using the values of $P(D)$, $P(DD)$, $P(W)$ and $P(WW)$ the probability of the continuation of dry/wet spell of different lengths in each 10-day period has been calculated by the following formulae :

$$P(Wy) = P(W) \times P\ (WW)^{y-1} \qquad (5)$$

$$P(Dy) = P(D) \times P\ (DD)^{y-1} \qquad (6)$$

where, $P(Wy)$ and $P(Dy)$ are the probabilities of y consecutive wet days and dry days respectively in a particular 10-day period.

3. The probability of a dry day $P(D)$ and wet day $P(W)$ in each 10-day period for the three months of northeast monsoon season is given in Table 1. It may be seen that the probability of dry day far exceeds that of a wet day in any 10-day period. The lowest probability of 60% is observed during 1-10 November period. After 10 December, when the northeast monsoon begins to withdraw the probability of a dry day becomes significantly large, exceeding 80%. Similarly, the highest probability of a wet day, i.e. 40%, is observed during 1-10 November when the monsoon activity appears to be at its peak (IMD 1973).

TABLE 2

10-day periodwise probability of consecutive dry/wet spells of different lengths

10-Day period	Probability of consecutive wet spell			Probability of consecutive dry spell		
	3 Days (%)	4 Days (%)	5 Days (%)	3 Days (%)	4 Days (%)	5 Days (%)
1-10 Oct	1	0	0	42	31	23
11-20 Oct	1	0	0	48	38	30
21-31 Oct	7	3	1	39	30	23
1-10 Nov	9	4	2	21	13	8
11-20 Nov	4	2	0	40	30	22
21-30 Nov	3	1	0	52	43	36
1-10 Dec	3	1	0	41	30	22
11-20 Dec	0	0	0	70	62	55
21-31 Dec	0	0	0	79	74	69

3.1. The probability of dry days preceded by another dry day, $P(DD)$, and that of wet days preceded by another wet day, $P(WW)$, is also given in Table 1. A glance of this table reveals that the values of $P(DD)$ are generally more than that of $P(D)$ in all the 10-day periods. As observed in the case of $P(D)$, here also probability of dry days preceded by another dry day is lowest during 1-10 November. Surprisingly, $P(WW)$ is invariably larger than $P(W)$ except during 1-10 October.

3.2. 10-day durationwise probabilities of the continued dry/wet spells of different lengths have been shown in Table 2. The probability of consecutive wet days was nearly zero for 5 consecutive days. Similarly, the values become low when the NE monsoon starts withdrawing after 11 December. In the active monsoon months of November, the probability is highest, i.e., 9% for 3 consecutive wet days during 1-10 November. During 21-31 October also this probability is comparable (i.e., 7%). In each of the 10-day periods between 21 October and 10 November, 4 consecutive wet days have just 3-4% chance.

3.3. In contrast, even 5 consecutive dry days also have a comparatively large probability, particularly after first 10-day period of December when such probability exceeds 50%. For obvious reasons, the probability increases as the length of dry spells decreases. Thus, whereas for 4 consecutive dry days in second and third 10-day periods of December the probability is more than 60%, for 3 continuous dry days it exceeds 70% in these two periods.

3.4. In his study, Sarkar (1994) found that during northeast monsoon at Madras expected frequency of dry and wet spell of different lengths fits well with the observed values. A closer look at Table 3 (source: Sarkar 1994) further reveals that theoretically the largest wet spell of 9 days can be expected in November followed by 8 days each in October and December. However, a wet spell of 12 days' duration was also found to occur in November. Expected length of a dry spell is seen to be maximum, i.e., 31 days during December. During October and November maximum expected length of dry spell is 22 to 23 days.

4. Following conclusions emerge out from the study:

(i) The probability of a day being wet is highest during 1-10 November, when the northeast monsoon is most active.

(ii) Three consecutive wet days have the highest chances of occurrence during 1-10 November.

(iii) After 10 December, when the northeast monsoon starts receding, the probability of 5 consecutive dry days is significantly large.

(iv) Maximum length of a dry spell can be expected during December while the largest wet spell of 9 days is possible in November.

TABLE 3

Expected and observed frequencies of the lengths of dry and wet spells

Length of the spell (Days)	Wet spell						Dry spell					
	October		November		December		October		November		December	
	Obs	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs	Exp
1	57	49	43	40	27	29	27	21	27	17	12	7
2	27	27	30	26	22	16	18	18	18	15	6	6
3	9	15	19	17	9	9	14	15	14	13	10	6
4	8	8	7	11	5	5	12	13	10	11	6	5
5	4	5	4	7	1	3	12	11	8	9	4	5
6	3	3	6	4	1	2	10	9	7	8	4	4
7	2	1	2	3	2	1	8	8	6	7	5	4
8	2	1	0	2	0	1	4	6	3	6	6	4
9	0	0	0	1	0	0	5	5	4	5	4	4
10	1	0	0	0	0	0	1	4	3	4	3	3
11	1	0	1	0	0	0	6	4	3	4	2	3
12	0	0	1	0	0	0	3	3	1	3	2	3
13	0	0	0	0	0	0	4	3	2	.3	2	3
14	0	0	0	0	0	0	2	2	3	2	2	2
15	0	0	0	0	0	0	2	2	1	2	3	2
16	0	0	0	0	0	0	1	2	1	2	3	2
17	0	0	0	0	0	0	2	1	2	1	3	2
18	0	0	0	0	0	0	0	1	1	1	3	2
19	0	0	0	0	0	0	1	1	2	1	1	2
20	0	0	0	0	0	0	0	1	0	1	1	1
21	0	0	0	0	0	0	0	1	0	1	1	1
22	0	0	0	0	0	0	1	1	2	1	1	1
23	0	0	0	0	0	0	1	0	1	1	1	1
24	0	0	0	0	0	0	0	0	0	0	1	1
25	0	0	0	0	0	0	0	0	0	0	0	1
26	0	0	0	0	0	0	0	0	1	0	2	1
27	0	0	0	0	0	0	0	0	0	0	0	1
28	0	0	0	0	0	0	0	0	0	0	0	1
29	0	0	0	0	0	0	0	0	0	0	0	1
30	0	0	0	0	0	0	0	0	0	0	0	1
31	0	0	0	0	0	0	0	0	0	0	1	1

Obs - Observed, Exp - Expected

References

Agnihotri, Y., Bansal, R.C. and Pralhad Singh, 1984, "Spell distribution and weather cycle at Chandigarh", *Mausam*, 35, 1, 99-102.

Basu, A.N., 1971, "Fitting of Markov Chain Model for daily rainfall data at Calcutta", *Indian J. Meteor. Geophys*, 22, 1, 67-74.

Bhargava, P.N., Narain, P., Sing, D. and Asha Saxena, 1977, Monograph on "Statistical studies on the behaviour of rainfall in a region in relation to a crop", Instt. Agr. Res. Stat., New Delhi.

India Met. Dep., 1973, "Northeast monsoon" FMU Report No. IV-18.4

Medhi, J., 1976, "A Markov Chain Model for the occurrence of dry and wet days", *Indian J. Meteor. Hydrol. Geophys.* 27, 4, 431-435

Pandharinath, N., 1991, "Markov Chain Model probability of dry, wet weeks during monsoon period over Andhra Pradesh", *Mausam*, 42, 4, 393-400.

Sarkar Jayanta, 1994, "The length distribution of weather cycles and dry and wet spells at Madras during the northeast monsoon months", *Vayu Mandal*, 24, No. 3-4, 77-80

Sundararaj, N. and Ramchandra, S., 1975, Markov dependent geometric models for weather spells and weather cycles - A study, "*Indian J. Meteor. Hydrol. Geophys.*, 26, 2, 221-226.

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